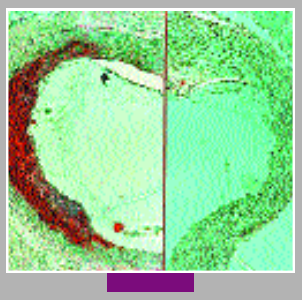
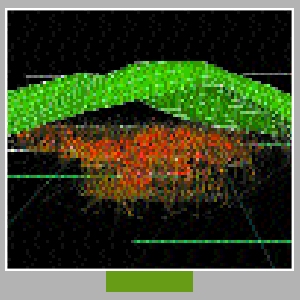
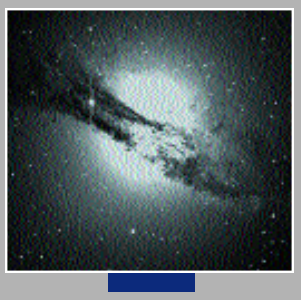
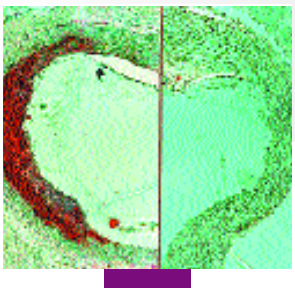
# Laboratory Directed Research and Development

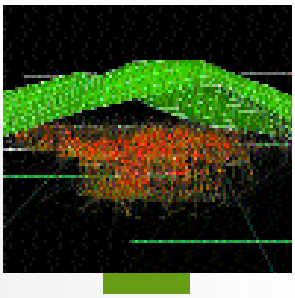
ERNEST ORLANDO LAWRENCE BERKELEY NATIONAL LABORATORY

# Research in the National Interest

The Federal government has long recognized the need to support innovative research at the National Labs, understanding that discretionary funds are an important element in assuring optimal scientific productivity. By granting researchers a small reserve of funding in a timely and direct way, the Laboratory Directed Research and Development (LDRD) at Berkeley Lab has provided a means to grow promising new scientific research projects, often enabling researchers to make rapid and significant contributions in their fields. LDRD is frequently the first source of support for research that is at the forefront of its discipline, addressing science and technology challenges that are of critical national interest. Over a five year period, Berkeley Lab's LDRD program has funded 343 projects. These projects lay the foundation for future work in support of DOE missions of Energy Security, National Security, Environmental Quality, and Science Leadership. Many LDRD projects have played a key role toward the development of larger DOE and national research programs, such as proof-of-principle studies that led to the creation of Berkeley Lab's Advanced Light Source, the world's brightest source of soft x-ray light; the design of the B Factory at SLAC, a physics experiment to help researchers understand the fundamentals of charge/parity violation; as well as numerous other scientific breakthroughs, a few of which are highlighted here. Berkeley Lab's LDRD program is a critical tool for attracting and retaining skilled and innovative scientists. Because it frequently supports the beginning of new projects that involve graduate students and postdoctoral fellows, LDRD also contributes to the Laboratory's ongoing mission to educate future scientists. Considering the relatively small amount of funding, about three percent of the Laboratory's budget, Berkeley Lab's LDRD offers a high rate of return for a modest investment.



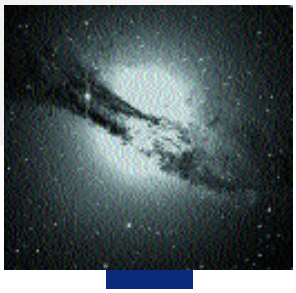
# Managing for Success



The Berkeley Lab LDRD program is managed in compliance with Congressional and Department of Energy requirements and oversight processes. All funded projects support work in forefront areas of science. Areas eligible for support include the following.

- Advanced study of hypotheses, concepts, or innovative approaches to scientific or technical problems;
- Experiments and analyses directed toward "proof of principle" or early determination of the utility of new scientific ideas, technical concepts, or devices; and
- Conception and preliminary technical analyses of experimental facilities or devices

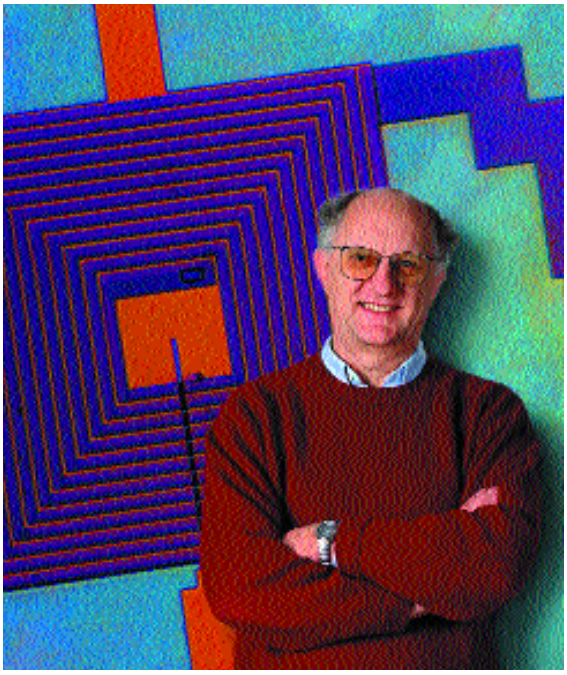
Proposals are evaluated by scientific and management peer review prior to selection. Typically the Laboratory Director issues a Call For Proposals in February prior to the fiscal year of funding, with submission due to Division Offices in approximately two months. There is a review and ranking of proposals at the division level, after which they are forwarded to the Directorate for review and evaluation by laboratory managers and/or other independent peer reviewers as appropriate. Final selection is by the Laboratory Director with assistance from the Deputy Director for Research. Consistent with the program requirements for the DOE national laboratory system, projects cannot augment programmatic funding, are limited to three years maximum, and are subject to audits and other relevant oversight procedures. An annual report is required from each project two months after the end of the fiscal year.



# Ultra-Sensitive Devices Using High-Temperature Superconductors

RESEARCHER ***John Clarke***

YEARS OF GRANT ***1988-1990***



Berkeley Lab physicist John Clarke with a magnified image of a high temperature superconducting quantum interference device, or SQUID, integrated with a multi-layer flux transformer. This device remains the world's most sensitive magnetic field detector that operates at liquid nitrogen temperatures.

High-temperature superconductors are brittle ceramics; fabricating them into miniature electronic devices requires novel techniques and architectures. Using laser deposition, John Clarke and his team sandwiched an insulating layer between two thin films of the high-temperature superconductor YBCO (yttrium barium copper oxide) to create a flux transformer, which converts a magnetic field to electrical current. By combining this miniature flux transformer with a SQUID (superconducting quantum interference device), fabricated on a separate chip of YBCO, the Clarke group in collaboration with industry created the world's most sensitive magnetometer at liquid nitrogen temperatures, capable of recording fluctuations in the magnetic field of a beating human heart—one of the first practical applications of high-temperature superconductors. WW

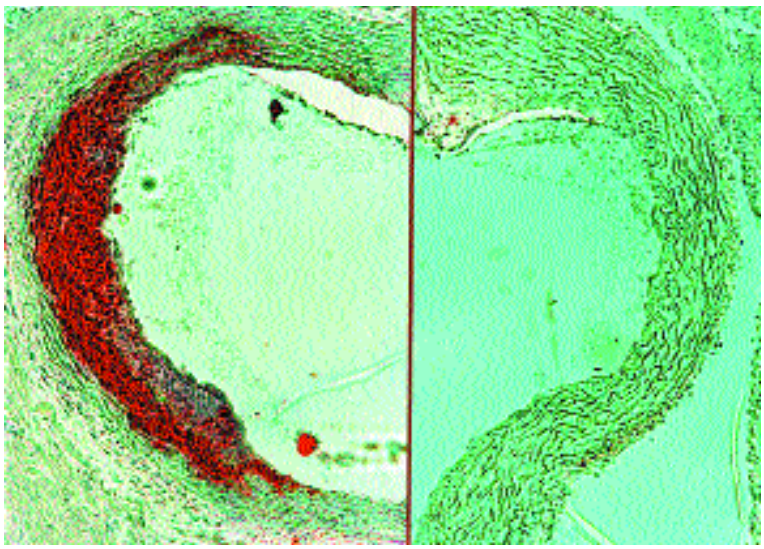
Scanning a SQUID over a one-dollar bill reveals the variations in the magnetic field produced by the ink particles.

# Genetic Mechanisms of Heart Disease

RESEARCHER ***Ronald Krauss***

YEARS OF GRANT ***1988-1990***

Berkeley Lab researchers have been at the forefront of research showing that certain forms of blood cholesterol affect risk of heart disease. The LDRD project led by Ronald Krauss showed that one common genetically determined type of cholesterol was a particularly strong indicator of risk in many apparently healthy subjects. Other studies initiated in this LDRD led to the creation of new strains of mice, including one with a human gene that protects arteries from the effects of high cholesterol, and another with a human gene that increases the risk of atherosclerosis. Combining the basic research, animal models, and population studies initiated in this research, Krauss and his collaborators discovered new genetic disorders predisposing a large proportion of the population to risk of heart attack and identified important genetic influences on the health effects of fat in the diet. Their growing understanding of the molecular and genetic bases of heart disease has led to new approaches to its diagnosis and management used throughout the country.

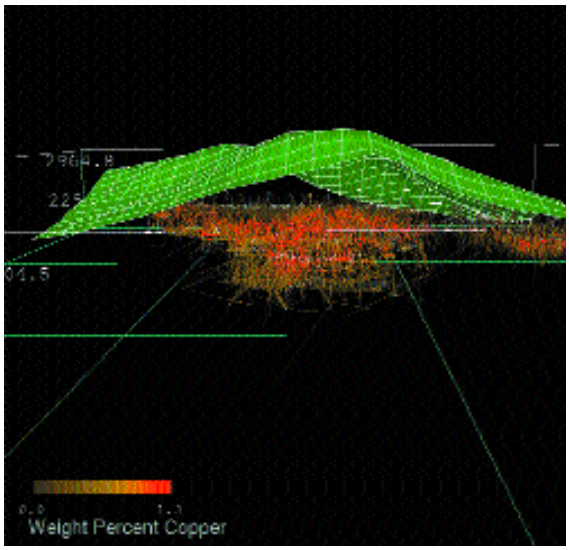


**Research seeded by LDRD revealed that after several months on high-fat diets, non transgenic mice developed numerous fatty deposits in their arteries (left) while transgenic mice with high levels of human high-density lipoproteins and ApoA-1 had almost none.**

# Modeling the Evolution of Ore Deposits in 3-D

RESEARCHERS *Karsten Pruess*
*George Brimhall*

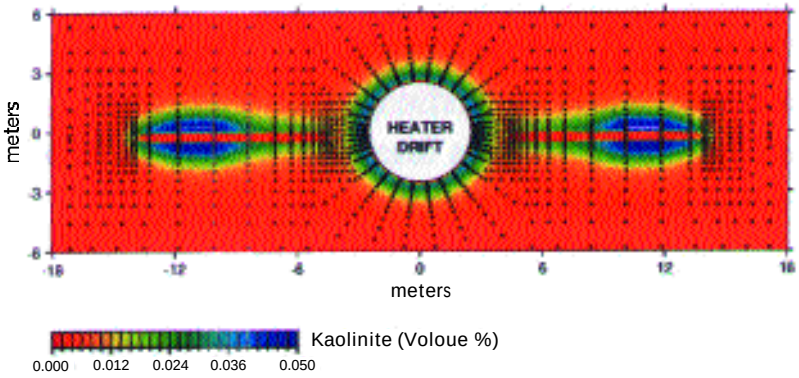
YEARS OF GRANT *1996-1999*




LDRD researchers Karsten Pruess and George Brimhall studied the copper deposits buried inside a mountain in Chile using half-a-million assay measurements collected from 11,000 boreholes. Employing high-speed computers to crunch these numbers into easily understood 3-D images can help evaluate the origin of the deposits and determine the best strategies for recovering subsurface deposits of minerals.

A unique set of real data from 11,000 drill holes in the El Salvador mine, in the Atacama Desert of northern Chile, was used to simulate the geologic evolution of the mine's ore deposits in three dimensions. Karsten Pruess, George Brimhall, and coworkers used a supercomputer to calculate and visualize the flow and chemical reactions of fluids through the porous rock. To show how the mine's copper-bearing minerals were massively enriched, their program took into account the effects of erosion, uplift, hydrogeologic conditions, and ancient climate changes. This computer model will not only aid future exploration for ore deposits and environmental management of associated waste, but is already being applied to help assess and plan the remediation of chemical, radioactive, and other waste at Department of Energy and industrial sites. WW

The simulation developed under this LDRD has already been applied to DOE's Yucca Mountain site to study how the heat from nuclear waste will affect the geological conditions thermally, hydrologically, and chemically. This figure shows a result of such an experiment.

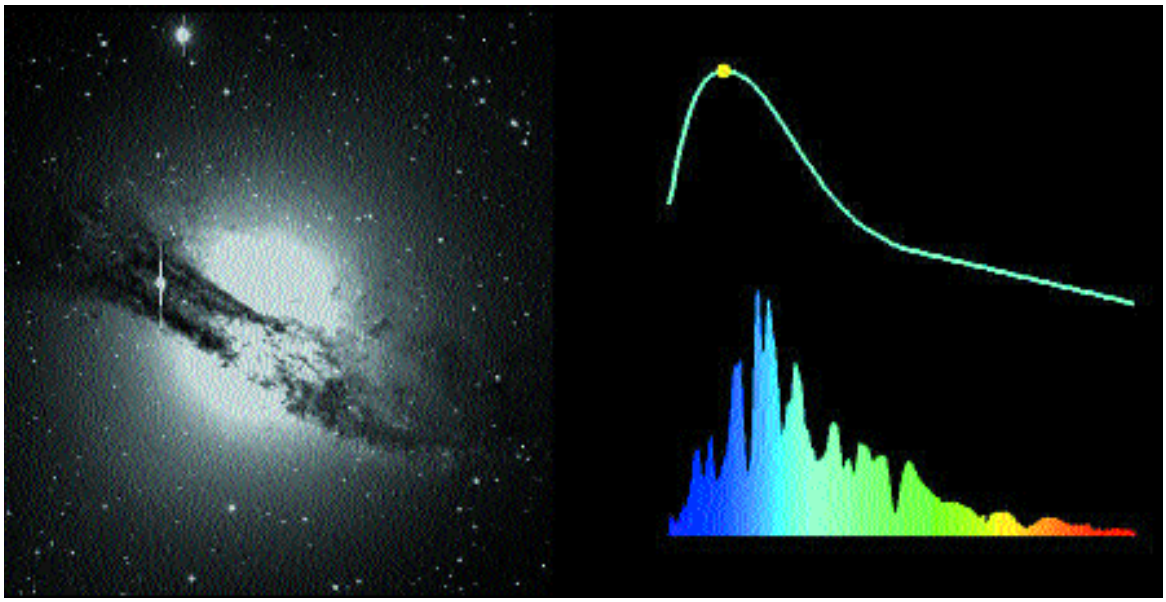


# Computing the Parameters of the Universe

RESEARCHER *Saul Perlmutter et al*

YEARS OF GRANT *1996-1999*

For over ten years the international Supernova Cosmology Project led by Saul Perlmutter has compared the distance and apparent brightnesses of dozens of type Ia supernovae, using observations of these astronomical "standard candles" to determine the fundamental parameters of the universe. But to insure that young, nearby supernovae could be reliably compared to ancient, distant ones, supercomputers were needed to analyze the spectra and model different scenarios of stellar explosion, examining such factors as the effects of intergalactic dust and the lack of heavy elements in the early universe. The results underpin the astonishing discoveries that only a third of the density of the universe is due to matter; the rest is mysterious "dark" energy, and which in turn is causing the universe to expand at an ever-accelerating rate. WW



**Three simulated representations of a recent supernova.The image at left shows how a supernova appears as it brightens and fades. The graph at upper right shows this brightness as a function of time; the bottom right shows how the spectrum of the supernova changes during this same period. Research funded in part by LDRD helped scientists understand data from these exploding stars to determine the fate of the universe.**

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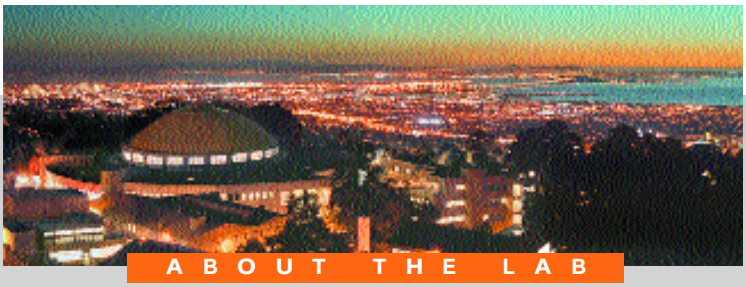
**For more information**
**Visit the LDRD website:**
**http://www.lbl.gov/Publications/LDRD/index.html**



## ABOUT THE LAB

**Ernest Orlando Lawrence Berkeley National Laboratory (Berkeley Lab) has been a leader in science and engineering technology for more than 65 years, serving as a powerful resource to meet national needs. Operated for the Department of Energy, Berkeley Lab is dedicated to performing leading edge research in the following core competencies:**

- **Computational Science and Engineering;**
- **Particle and Photon Beams;**
- **Bioscience and Biotechnology;**
- **Characterization, Synthesis, and Theory of Materials;**
- **Advanced Technologies for Energy Supply and Energy Efficiency;**
- **Chemical Dynamics, Catalysis, and Surface Science;**
- **Advanced Detector Systems; and**
- **Environmental Assessment and Remediation.**

**The Laboratory also operates unique user facilities available to qualified investigators, including the Advanced Light Source, the National Center for Electron Microscopy, the National Energy Research Scientific Computing Center, and the 88-Inch Cyclotron. In addition to its work for the Department of Energy, Berkeley Lab conducts research for other government agencies, such as the National Institutes of Health and the National Aeronautics and Space Administration, as well as private companies.**

**The oldest of the Department of Energy national labs, Berkeley Lab has the distinction of being located next to one of the world's foremost universities—the University of California at Berkeley. The Lab employs a staff of 4,127 people, a portion of whom are faculty and students, and hosts nearly 1,500 participating guests each year. It has an annual budget of about $420 million, and is managed by the University of California.**

Design: Niza Hanany